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Chemical Effects of Light.

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Essay on the Chemical effects of Light.

"The evidence on which the doctrines of Chemistry
"rest, does not amount to strict demonstration, but
"consists of a chain of inductions drawn from obser-
"vation or experiment, or sometimes only inferred from
"analogy."

Professor Murray's elements of Chemistry.

Compelled by the laws and customs of the University of Pennsylvania, to offer something as a preliminary to an examination for a degree in medicine, I have pursued to offer this essay, not as a production worthy that honor, but as a weak attempt towards the attainment of it. In this essay, I shall offer some remarks on the chemical effects of light; and for greater convenience, I shall deliver my observations under the three following heads.

In the first place, consider the action of light on bodies chemically united. Secondly,

Make some inquiries into the combinations of light,

And lastly, Infer from analogy its relation to other chemical agents.

On the nature of this peculiar substance, there are two theories, each of which has its advocates, among the learned of Europe and America. Innumerable experiments have been made, and the most ingenious reasoning advanced, in support of each, with the effect perhaps of establishing more firmly each theory on the minds of its respective adherents. It is foreign to this essay to enter into the consideration of either, I shall therefore hazard this observation only: that I conceive each of them ingenious, & each plausible – the theory of Newton to possess the weight of experiment, while that of Huygens is established on the most certain foundation REASON.

We are indebted to Schule, Scheele, Wollaston & Ritter, for knowledge of some very interesting facts, relative to the chemical rays of light. These are found to occupy, in greatest abundance, that part of the spectrum, which possesses the heating power in the least degree — the chemical effect decreasing as you approach the red ray — while the heating power is to be found strongest in the red, decreasing as you approach the violet ray. Mr. Ritter and Dr. Wollaston, from direct experiment, have carried the analogy farther; as the heating power of the solar rays is greatest beyond the red, so the chemical effect is greater beyond the violet ray. Mr. Ritter has come to the conclusion, from the result of his experiments, that there are two species of invisible rays, — one calorific, & which promotes oxidation — the other species capable of separating oxygen, when it is combined, & of counteracting its combination. — It has been affirmed, says Professor Murray, that this gentleman, by transmitting the coloured rays through different prisms, has separated them from the chemical rays, and produced a coloured spectrum totally devoid of chemical action.

Light exerts an effect truly chemical, on many organic and inorganic substances. If fresh vegetables are placed in water, and exposed to the action of the sun rays, oxygen gas will be evolved in considerable quantity,

by the decomposition of the water. D. Woodhouse in a note to his edition of M. Chaptal's Chemistry brings forward another proof of the chemical agency of light, by ascertaining that there is a quantity of carbonic acid gas in the water, & that it is this which is decomposed by the superior affinity of the agent — Dr Priestley made a number of experiments on atmospheric air impregnated with gases noxious to animal life, & from the result of them it appears, that the air was uniformly restored to its pristine purity, by being exposed to the action of light when in contact with fresh vegetables. M. Senebier advances an opinion founded on experiment, tending to prove the chemical action of light; that the addition of an acid increases the quantity of oxygen gas which is disengaged, provided the water is not too much acidulated.

The affinity of oxygen for carbon is known by all practical chemists to be very great, so great that oxygen at one time stood first in the tables of chemical affinity for its attraction for carbon; to produce a decomposition, argues the incapity of a powerful agent, or a substance possessing a stronger attraction for one of the principles, than they do for each other — The carbonic is not the only instance among the class of bodies termed the acids, which attests the identity of light as a chemical agent, by parting with considerable quantities

of its oxygen, under its influence.

The oxymuriatic & nitric acids give off a large proportion of their oxygen, when exposed to the influence of the sun's rays — we here have a most decisive proof that it is the agency of light alone, and not heat, which effects the decomposition; for these acids may be converted into the gaseous state very readily, by the application of heat, and without decomposition, provided the rays of light be excluded. It may be observed, however, that the chemical action is prevented altogether if a substance be interposed capable of intercepting and absorbing the rays of light; if the bottle be full, and closed with a glass stopper there is no change effected — the mechanical pressure appearing sufficient to counteract the decomposing power of the light. These altho' apparently depreciating the power of the agent, in promoting chemical decomposition, are by no means evidences against it; on the contrary, proving that light is influenced by specific and determinate laws, with other chemical agents.

The great variety of metallic oxides, and the combinations of these oxides with acids, which acknowledge the de-oxidizing power of light, is no small evidence of its chemical agency. The red oxide of mercury, if exposed to the rays of the sun, will lose a portion of its

oxygen, and a change of colour will be produced.

It has been observed, by the celebrated Lavoisier, when speaking of the process for obtaining oxygen gas from this salt by heat, that "as the oxygen gas never appears till the retort becomes red, it seems to prove the principle established by M. Berthollet, that an obscure heat can never form oxygen gas, and that light is one of its constituent elements." The muriate of gold & silver, & the nitrate of silver have been proved to be capable of total decomposition, by the action of light, from the experiments of Schule, Berthollet, & Mrs Fulhame, the ingenious author of an essay on combustion.

These experiments prove that light not only possess the power of robbing compounds of their oxygen, but also of their acid — In some of the experiments just alluded to, of M. Schule & Mrs Fulhame, the decomposition of the muriate of gold, & nitrate of silver was so complete, that the metals were obtained completely revived. The influence of light on the organized productions of nature, is very remarkable. Organization, sensation, spontaneous motion, and all the operations of life, says Lavoisier, exist only at the surface of the earth, and in places exposed to the influence of light, and

without it nature itself would be lifeless & inanimate".
Vegetables when deprived of light, become insipid, inodorous, brittle, and lose that agreable variety of shade, which is so eminently conspicuous, in this portion of the productions of Nature. How these changes are produced, is a question solved with difficulty. Mr. Murray appears disposed to think, they depend upon the accumulation of oxygen in the plant, which is disengaged thro' the influence of light.

On animals many the same effects are produced; Man is indebted to light for his colour & the most numerous of his pleasures; and the variety & brilliancy of hue met with in animals, particularly of the feathered tribes of tropical regions, fully establishes the truth of the position. Light has been observed to have considerable influence on the mass of blood, by Mr. Trent, of Richmond, who published his inaugural dissertation, some years ago, in this city. This gentleman exposed human blood to the influence of light, taking every precaution to exclude atmospheric air, & avoid fallacy. In these experiments, he uniformly found a change of colour to be produced, that resembled the vermi-

-lion induced by the action of atmospheric air in the lungs. The colour was not so intense as that of arterial blood, or that of blood submitted to the conjoined action of air and light; but sufficient to ascertain that some change was effected, & his experiments were so varied, as to prove the result, to be the action of light alone.

Was I to attempt collecting all the facts that might be adduced, in favour of the chemical agency of light, the patience of my reader would be worn out, & this would be extended farther than the limits of an essay. We have not only the facts already mentioned, but the opinion of many celebrated philosophers, whose judgments have been matured by reflection, deliberation & experience. "We can no longer, says Chaptal, consider light as a merely physical substance; the chemist perceives its influence in most of his experiments, & finds it necessary to attend to its action which modifies his results, & its effects are no less evident in the various phenomena of nature than in the operations performed in our laboratories". Mr. Murray, whose writings stand among the most valuable productions of British genius, and whose observations are entitled to our attention, observes, that "next to oxygen, light is perhaps the most extensive in its influence of any chemical agent. These two principles may even be regarded as antagonists, the combination of-

oxygen being generally attended either by the separation of light in a sensible form, or its transition into a state of new combination; while oxygen is scarcely ever disengaged without the interpunce of fire or combined light".

Under our second head, we propose making some inquiries into the combinations of light. By analysis or synthesis, we usually ascertain the existence of a principle, in a compound body. That light is capable of entering into combination, may be proved by either. By analytical experiment, we ascertain the presence of light in oxygen gas. If an ignited piece of charcoal be placed in a vessel of oxygen gas, the gas will disappear, with the evolution of light; and carbonic acid gas will be formed. Mr. Davy proves by the following experiment, that light is a principle of oxygen gas, & establishes in the most unequivocal manner, that light does not exist in carbonic acid gas. "A small gun lock armed with an excellent flint, was snapped in a vessel filled with oxygen gas. The particles of steel separated by collision were the most brilliant that can be imagined; and these particles, examined by a magnifier, were found to be converted into black oxyd of iron. The same experiment was made in a vessel filled with carbonic acid gas, the iron was fused, but no light was liberated". We have already stated, that the existence of light in oxygen gas may be ascertained by synthetic arrangement. It appears to be pro-

pretty understood in chemical combination, that a body which is capable of one combination, is or may be combined, with a variety of other substances. Mr Murray when speaking of light, observes, "if the opinion be maintained, that it is a component principle of combustible bodies, it will be extricated in deflagration from the inflammable body; while if it be a constituent principle of oxygen gas, it may still be derived from this source, for when oxygen unites with nitrogen, no light is extricated, and therefore if oxygen gas do contain light, this light must remain combined with it, as it exists in the nitrate of potash". May we not infer from analogy that it enters into many other chemical combinations. The combinations of the same principles, in different proportions, will produce compounds, differing, in their physical or chemical properties, from the original. Of this we have an example in the combinations of oxygen & nitrogen — In these combinations the peculiar properties of the compound depend on the presence of each of the constituents — Abstract one, & you destroy the compound — proving that each constituent, confers specific, & determinate properties. Most of the writers on chemical subjects appear disposed to bestow greater power on one substance, than another, in chemical combination — thus, oxygen is preeminently called the principle of acidification. To

prove that this is incorrect, it is only necessary to propose two questions. Does oxygen, in the purest form we can obtain it, possess in itself, one property of an acid? Are acid properties compound, or all its combinations?

I conceive that the existence of light in oxygen gas, is sufficiently clear. What then becomes of this principle, when oxygen & hydrogen are combined to form water? In this process the evolved heat is intense, and the light should be visible, & in the same ratio, if it was set free by the combination; on the contrary, the light produced by the combustion is by no means in the proportion that may be evolved by other means. If light exists in combination with oxygen, and is not set free by the combination of this with hydrogen, - the conclusion must be that it makes a part of the product.

I cannot conceive of any absurdity attached to a conclusion of this nature. Instances almost innumerable may be adduced analogous to this, of one body entering into combinations with others & producing substances totally distinct & in some instances directly opposite in their properties. Thus oxygen & nitrogen in different proportions form atmospheric air, nitrous oxide, nitrous acid & nitric acid - Oxygen has been proved to be the principle of acidification & alcalescence - Hydrogen, the lightest of bodies in its gaseous state, is found to exist in the hardest, & rationally supposed to form a constituent principle of the metals, substances of the greatest specific gravity.

That class of bodies termed the phosphori possess the property of combining with light when exposed to it, & of emitting it again when carried into a dark place. The expulsion of the light appears to be very much accelerated, by the application of heat. It appears from the experiments of Mess^rs Du Fay & Wilson, as related by Professor Murray, that the light emitted from phosphorescent bodies is not influenced by a single prismatic ray. If a piece, for instance, which in the dark gives a white light, have a red light thrown upon it, or be exposed to any other ray, it still continues to give out an apparent white light." "This fact," says Murray, "are favourable to the conclusion, that the light which phosphorescent bodies emit, is that which they had previously absorbed, and have led some to infer that they thrown by emitting their own light, & that exposure to light is only necessary to excite this & cause it to be thrown off. It is not improbable, however, that the different varieties of light are convertible into each other, and on this supposition the fact may be accounted for, in conformity with the common theory of phosphorescence".

Can it be possible that light is purely physical in its ^its^ on vegetables — Reason & true philosophy answer in the negative. I conceive that the production of colour, odour, pungency of taste, &c, are as much the result of a chemical action, as the production of co-

lour in dying, the formation of ammonia, or nitric acid. M. Lavoisier observes, that experiments upon vegetation give reason to believe, that light combines with certain parts of vegetables. Mr. Davy has ascertained by experiment, that the colour of vegetables depends on light, & when this is excluded they become white, notwithstanding they are naturally of a deep colour; and, that flowers naturally white, when exposed to an intense light, become highly coloured. Some plants, possessing deleterious properties, become perfectly harmless by being kept in a dark place. M. Fourcroy observes, that not only the colour of vegetables depends on light, but to it they are indebted for their smell, taste, combustibility, & nutritious principle. Hence aromatic substances, resins, volatile oils, and their colouring matter, of so much value for their medicinal & dying, are peculiar to southern climates, where the light is more constant and intense. D. Barton observed in his lectures, that plants exposed to the action of the suns rays, yield most sugar.

In the combustion of different substances, we frequently must observe, that the colour of the flame is not always similar. May not the variety of shade, be owing to the inflammable, or product of the inflammation, combining with some of the rays of light, & to the evolution of the others? Or do the rays of light carry off a portion of the combustible, & thus tinge it of any colour, depending on the combustible? The former is the most probable.

* In these experiments it was inflammable matter in the c
case, & the action of the charcoal in the other, which gave r
to his error.

* Murray's Chemistry, Edit. 2. Vol. 1 P. 6

The arguments brought forward, I conceive to establish the plausibility of the combinations of light sufficiently clearly. It is a more difficult task to explain the nature of the combination – to ascertain the particular rays of light, & the parts with which they combine. I make no doubt that some of the effects of light are explicable on ~~the~~ its deoxidizing property; Yet I think it equally probable that the rays are in some instances combined with some of the constituent principles of the vegetable.

Under my third head I propose to make some inquiries into the relation of light, to other chemical agents.

Heat and light were at one time thought to be one and the same – or rather one was thought to be the effect of the other; Since M. Lavoisier declares, "we are unable to determine whether light be a modification of caloric, or, on the contrary, caloric be a modification of Light."

The ingenious Count Rumford made some experiments, to prove that the chemical powers of light, were not independent of ~~the~~ the heat that was excited – His experiments appeared to warrant a conclusion of this kind; but unfortunately for this theory, the result was proved, by Mr. Pelham, & Berthollet who repeated these experiments, not to be caused by the action of heat, but by some extraneous matter.

When a substance cannot be subjected to minute examination

because it is unconpensable — or when we cannot obtain the
parts we wish to investigate in sufficient quantity or in a dis-
ble form — we shall be justifiable in judging of the nature of
it, from its effects & the analogous effects of others.
Amidst the number of agents with which the science of
Chemistry is enriched, there is none, which I conceive to
be so nearly allied to light, as galvanism. This must
be necessarily hypothetical, yet when we reflect on the anal-
logy which subsists between them, in their effects on bodies,
submitted to their action; and when we observe the great
variety of compounds produced from a few principles, our a-
stonishment wears off, & we begin to look on it with
an eye of greater complacency. The agency of galvanism
appears to consist in violent attraction and repulsion, pos-
sessing the property of conveying the principles of the de-
composed substance to a distance, & even through substances
which have a strong affinity for them. This we do not ob-
serve in the agency of light — May not this be owing
to our not being acquainted with an apparatus, which
could concentrate the rays of light sufficiently, & exclude
those which do not possess a chemical power? By far
the most important agency of galvanism is that which
subserts combination & gives rise to chemical decomposi-
tion — possessing a power greater than that of any —

agent hitherto known & which may be increased to any extent by enlarging the apparatus. The great analogy between Light & galvanism, I conceive to exist, in the power of one, in occasioning decomposition, & abstracting oxygen; and that which is termed the positive effect of the other. We have mentioned a number of substances, which are powerfully acted on by light, & decomposed by the abstraction of their oxygen. And we have seen that light, is in some instances capable of separating the acid from a base, which has a powerful affinity for it. These are not the only arguments, in favor of the relation of the two agents. In a preceding part of this essay we have proved that light enters into combination to form nitric acid. Now the effects of galvanism may be produced by this, & other substances, into the composition of which, light enters. "If a series be formed of water, metal, & diluted nitric acid, the production of galvanism is evident, though not considerable: Mr. Davy observed, that a piece of charcoal, in contact at one of its surfaces with water, at another with nitric acid, shews signs of galvanism."* May not this be owing to the extrication of light from its combination, producing the effect of galvanism. When we reflect that so little is known of the particles of these agents & so much to be learned, that the only method we have of acquiring an accurate knowledge of either

* Mr Murray's Chemistry Part 2.

is by attentively observing the phenomena produced by them
on different bodies, & that each possesses the property of decom-
posing salts, acids, &c. by their specific power, May we not
infer that they are intimately connected, one with the o-
ther. Whatever may be the relation, which shall be found to
exist between them, certain it is, that their effects are in many
instances very similar — the difference, I conceive to be explica-
ble on the grounds of the great expansion of the chemical
particles of light, & the condensation of the galvanic influ-
ence — I have thus thrown a few unconnected thoughts together
on a subject, which has not made such rapid strides towards
perfection, as others have, that come equally under the consideration
of the natural philosopher & chemist. To Mr. Murray's System of
Chemistry I have been much indebted. I have taken the liberty
of transcribing many sentences from authors, which could not be
improved in other words, without doing an injury to the intention.
A number of circumstances might be urged to palliate the
imperfections of the composition — haste, bad health, & the anxiety ne-
cessarily attendant on a candidate for medical honors, whose
future success in life depends on the result — Was this juve-
nile production to be stripped of its borrowed feathers, it would
be naked indeed. Let me solicit your indulgence for the
errors contained in this, the first production of the —

Author.

Medical Effects

of

Light and Darkness.

Thos. Sutler Jr.

1809